

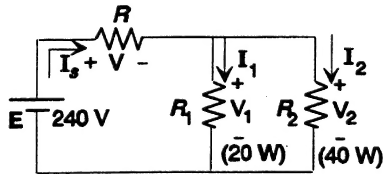
CHAPTER 19 (Odd)

1. a. $P_T = 60 \text{ W} + 20 \text{ W} + 40 \text{ W} = 120 \text{ W}$

b. $Q_T = 0 \text{ VARs}, S_T = P_T = 120 \text{ VA}$

c. $S_T = EI_s, I_s = \frac{S_T}{E} = \frac{120 \text{ VA}}{240 \text{ V}} = 0.5 \text{ A}$

d.



$$P = I_s^2 R, R = \frac{P}{I_s^2} = \frac{60 \text{ W}}{(0.5 \text{ A})^2} = 240 \Omega$$

$$V = I_s R = (0.5 \text{ A})(240 \Omega) = 120 \text{ V}$$

$$V_1 = V_2 = E - V = 240 \text{ V} - 120 \text{ V} = 120 \text{ V}$$

$$P_1 = \frac{V_1^2}{R_1}, R_1 = \frac{V_1^2}{P_1} = \frac{(120 \text{ V})^2}{20 \text{ W}} = 720 \Omega$$

$$P_2 = \frac{V_2^2}{R_2}, R_2 = \frac{V_2^2}{P_2} = \frac{(120 \text{ V})^2}{40 \text{ W}} = 360 \Omega$$

e. $I_1 = \frac{V_1}{R_1} = \frac{120 \text{ V}}{720 \Omega} = \frac{1}{6} \text{ A}, I_2 = \frac{V_2}{R_2} = \frac{120 \text{ V}}{360 \Omega} = \frac{1}{3} \text{ A}$

3. a. $P_T = 0 + 100 \text{ W} + 300 \text{ W} = 400 \text{ W}$

$$Q_T = 200 \text{ VAR(L)} - 600 \text{ VAR(C)} + 0 = -400 \text{ VAR(C)}$$

$$S_T = \sqrt{P_T^2 + Q_T^2} = 565.69 \text{ VA}$$

$$F_p = \frac{P_T}{S_T} = \frac{400 \text{ W}}{565.69 \text{ VA}} = 0.7071 \text{ (leading)}$$

b. —

c.
$$P_T = EI_s \cos \theta_T$$

$$400 \text{ W} = (100 \text{ V})I_s(0.7071)$$

$$I_s = \frac{400 \text{ W}}{70.71 \text{ V}} = 5.66 \text{ A}$$

$$I_s = 5.66 \text{ A} \angle 135^\circ$$

5. a. $P_T = 200 \text{ W} + 200 \text{ W} + 0 + 100 \text{ W} = 500 \text{ W}$

$$Q_T = 100 \text{ VAR(L)} + 100 \text{ VAR(L)} - 200 \text{ VAR(C)} - 200 \text{ VAR(C)} = -200 \text{ VAR(C)}$$

$$S_T = \sqrt{P_T^2 + Q_T^2} = 538.52 \text{ VA}$$

b. $F_p = \frac{P_T}{S_T} = \frac{500 \text{ W}}{538.52 \text{ VA}} = 0.928 \text{ (leading)}$

c. —

$$\begin{aligned}
 d. \quad P_T &= EI_s \cos \theta_T \\
 500 \text{ W} &= (50 \text{ V})I_s(0.928) \\
 I_s &= \frac{500 \text{ W}}{46.4 \text{ V}} = 10.776 \text{ A} \\
 \mathbf{I}_s &= 10.776 \text{ A} \angle 21.875^\circ
 \end{aligned}$$

$$\begin{aligned}
 7. \quad a. \quad R: P &= \frac{E^2}{R} = \frac{(20 \text{ V})^2}{2 \Omega} = 200 \text{ W} \\
 P_{L,C} &= 0 \text{ W}
 \end{aligned}$$

$$\begin{aligned}
 b. \quad R: Q &= 0 \text{ VAR} \\
 C: Q_C &= \frac{E^2}{X_C} = \frac{(20 \text{ V})^2}{5 \Omega} = 80 \text{ VAR}(C) \\
 L: Q_L &= \frac{E^2}{X_L} = \frac{(20 \text{ V})^2}{4 \Omega} = 100 \text{ VAR}(L)
 \end{aligned}$$

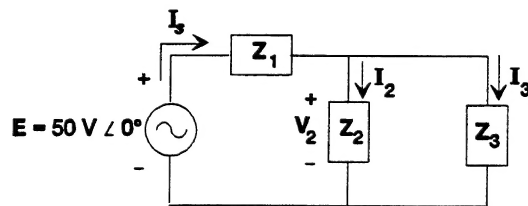
$$\begin{aligned}
 c. \quad R: S &= 200 \text{ VA} \\
 C: S &= 80 \text{ VA} \\
 L: S &= 100 \text{ VA}
 \end{aligned}$$

$$\begin{aligned}
 d. \quad P_T &= 200 \text{ W} + 0 + 0 = 200 \text{ W} \\
 Q_T &= 0 + 80 \text{ VAR}(C) + 100 \text{ VAR}(L) = 20 \text{ VAR}(L) \\
 S_T &= \sqrt{(200 \text{ W})^2 + (20 \text{ VAR})^2} = 200.998 \text{ VA} \\
 F_p &= \frac{P_T}{S_T} = \frac{200 \text{ W}}{200.998 \text{ VA}} = 0.995 \text{ (lagging)} \Rightarrow 5.73^\circ
 \end{aligned}$$

e. —

$$\begin{aligned}
 f. \quad I_s &= \frac{S_T}{E} = \frac{200.998 \text{ VA}}{20 \text{ V}} = 10.05 \text{ A} \\
 \mathbf{I}_s &= 10.05 \text{ A} \angle -5.73^\circ
 \end{aligned}$$

9. a-c.



$$X_L = \omega L = (400 \text{ rad/s})(0.1 \text{ H}) = 40 \Omega$$

$$\begin{aligned}
 X_C &= \frac{1}{\omega C} = \frac{1}{(400 \text{ rad/s})(100 \mu\text{F})} \\
 &= 25 \Omega
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{Z}_1 &= 40 \Omega \angle 90^\circ, \mathbf{Z}_2 = 25 \Omega \angle -90^\circ \\
 \mathbf{Z}_3 &= 30 \Omega \angle 0^\circ
 \end{aligned}$$

$$\begin{aligned}
 \mathbf{Z}_T &= \mathbf{Z}_1 + \mathbf{Z}_2 \parallel \mathbf{Z}_3 = +j40 \Omega + (25 \Omega \angle -90^\circ) \parallel (30 \Omega \angle 0^\circ) \\
 &= +j40 \Omega + 19.21 \Omega \angle -50.19^\circ \\
 &= +j40 \Omega + 12.3 \Omega - j14.76 \Omega \\
 &= 12.3 \Omega + j25.24 \Omega \\
 &= 28.08 \Omega \angle 64.02^\circ
 \end{aligned}$$

$$\mathbf{I}_s = \frac{\mathbf{E}}{\mathbf{Z}_T} = \frac{50 \text{ V} \angle 0^\circ}{28.08 \Omega \angle 64.02^\circ} = 1.78 \text{ A} \angle -64.02^\circ$$

$$\begin{aligned}
 \mathbf{V}_2 &= \mathbf{I}_s(\mathbf{Z}_2 \parallel \mathbf{Z}_3) = (1.78 \text{ A} \angle -64.02^\circ)(19.21 \Omega \angle -50.19^\circ) \\
 &= 34.19 \text{ V} \angle -114.21^\circ
 \end{aligned}$$

$$I_2 = \frac{V_2}{Z_2} = \frac{34.19 \text{ V } \angle -114.21^\circ}{25 \Omega \angle -90^\circ} = 1.37 \text{ A } \angle -24.21^\circ$$

$$I_3 = \frac{V_2}{Z_3} = \frac{34.19 \text{ V } \angle -114.21^\circ}{30 \Omega \angle 0^\circ} = 1.14 \text{ A } \angle -114.21^\circ$$

$$Z_1: P = 0 \text{ W}, Q_L = I_s^2 X_L = (1.78 \text{ A})^2 40 \Omega = 126.74 \text{ VAR}(L)$$

$$Z_2: P = 0 \text{ W}, Q_C = I_2^2 X_C = (1.37 \text{ A})^2 25 \Omega = 46.92 \text{ VAR}(C)$$

$$Z_3: P = I_3^2 R = (1.14 \text{ A})^2 30 \Omega = 38.99 \text{ W}, Q_R = 0 \text{ VAR}$$

d. $P_T = 0 + 0 + 38.99 \text{ W} = 38.99 \text{ W}$
 $Q_T = +126.74 \text{ VAR}(L) - 46.92 \text{ VAR}(C) + 0 = 79.82 \text{ VAR}(L)$

$$S_T = \sqrt{P_T^2 + Q_T^2} = 88.83 \text{ VA}$$

$$F_p = \frac{P_T}{S_T} = \frac{38.99 \text{ W}}{88.83 \text{ VA}} = 0.439 \text{ (lagging)}$$

e. —

f. $W_R = \frac{V_R I_R}{2f_1} = \frac{V_2 I_3}{2f_1} = \frac{(34.19 \text{ V})(1.14 \text{ A})}{2(63.69 \text{ Hz})} = 0.31 \text{ J}$

$$f_1 = \frac{\omega_1}{2\pi} = \frac{400 \text{ rad/s}}{6.28} = 63.69 \text{ Hz}$$

g. $W_L = \frac{V_L I_L}{\omega_1} = \frac{(I_s X_L) I_s}{\omega_1} = \frac{I_s^2 X_L}{\omega_1} = \frac{(1.78 \text{ A})^2 40 \Omega}{400 \text{ rad/s}} = 0.32 \text{ J}$

$$W_C = \frac{V_C I_C}{\omega_1} = \frac{V_2 I_2}{\omega_1} = \frac{(34.19 \text{ V})(1.37 \text{ A})}{400 \text{ rad/s}} = 0.12 \text{ J}$$

11. a. $I = \frac{S_T}{E} = \frac{5000 \text{ VA}}{120 \text{ V}} = 41.67 \text{ A}$

$$F_p = 0.8 \Rightarrow 36.87^\circ \text{ (lagging)}$$

$$E = 120 \text{ V } \angle 0^\circ, I = 41.67 \text{ A } \angle -36.87^\circ$$

$$Z = \frac{E}{I} = \frac{120 \text{ V } \angle 0^\circ}{41.67 \text{ A } \angle -36.87^\circ} = 2.88 \Omega \angle 36.87^\circ = 2.30 \Omega + j1.73 \Omega = R + jX_L$$

b. $P = S \cos \theta = (5000 \text{ VA})(0.8) = 4000 \text{ W}$

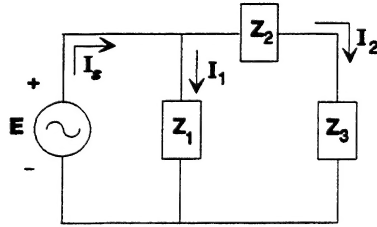
13. a. $P_T = 0 + 300 \text{ W} + 600 \text{ W} = 900 \text{ W}$
 $Q_T = 500 \text{ VAR}(C) + 0 + 500 \text{ VAR}(L) = 0 \text{ VAR}$
 $S_T = P_T = 900 \text{ VA}$

$$F_p = \frac{P_T}{S_T} = 1$$

b. $I_s = \frac{S_T}{E} = \frac{900 \text{ VA}}{100 \text{ V}} = 9 \text{ A}, I_s = 9 \text{ A } \angle 0^\circ$

c. —

d.



$$Z_1: Q_C = \frac{V^2}{X_C} \Rightarrow X_C = \frac{V^2}{Q_C} = \frac{10^4}{500} = 20 \, \Omega$$

$$I_1 = \frac{E}{Z_1} = \frac{100 \, V \angle 0^\circ}{20 \, \Omega \angle -90^\circ} = 5 \, A \angle 90^\circ$$

$$I_2 = I_s - I_1 = 9 \, A - j5 \, A = 10.296 \, A \angle -29.05^\circ$$

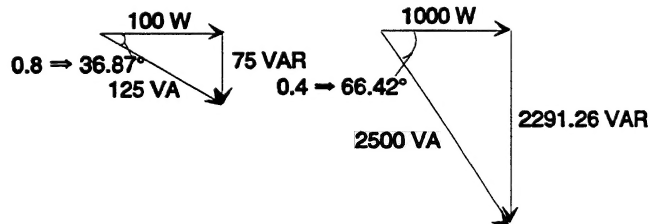
$$Z_2: R = \frac{P}{I^2} = \frac{300 \, W}{(10.296 \, A)^2} = \frac{300}{106} = 2.83 \, \Omega$$

$$X_{L,C} = 0 \, \Omega$$

$$Z_3: R = \frac{P}{I_2^2} = \frac{600 \, W}{(10.296 \, A)^2} = 5.66 \, \Omega$$

$$X_L = \frac{Q}{I_2^2} = \frac{500}{(10.296 \, A)^2} = 4.717 \, \Omega, X_C = 0 \, \Omega$$

15. a. $P_T = 100 \, W + 1000 \, W = 1100 \, W$



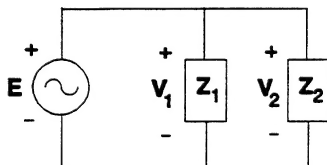
$$Q_T = 75 \, \text{VAR}(C) + 2291.26 \, \text{VAR}(C) = 2366.26 \, \text{VAR}(C)$$

$$S_T = \sqrt{P_T^2 + Q_T^2} = 2609.44 \, \text{VA}$$

$$F_p = \frac{P_T}{S_T} = \frac{1100 \, W}{2609.44 \, \text{VA}} = 0.4215 \, (\text{leading}) \Rightarrow 65.07^\circ$$

b. $S_T = EI \Rightarrow E = \frac{S_T}{I} = \frac{2609.44 \, \text{VA}}{5 \, A} = 521.89 \, V$
 $E = 521.89 \, V \angle -65.07^\circ$

c.



$$I_{Z_1} = \frac{S}{V_1} = \frac{S}{E} = \frac{125 \, \text{VA}}{521.89 \, V} = 0.2395 \, A$$

$$I_{Z_2} = \frac{S}{V_2} = \frac{S}{E} = \frac{2500 \text{ VA}}{521.89 \text{ V}} = 4.79 \text{ A}$$

$$Z_1: R = \frac{P}{I_{Z_1}^2} = \frac{100 \text{ W}}{(0.2395)^2} = 1743.38 \Omega$$

$$Q = I_{Z_1}^2 X_C \Rightarrow X_C = \frac{Q}{I_{Z_1}^2} = \frac{75 \text{ VAR}}{(0.2395 \text{ A})^2} = 1307.53 \Omega$$

$$Z_2: R = \frac{P}{I_{Z_2}^2} = \frac{1000 \text{ W}}{(4.790 \text{ A})^2} = 43.59 \Omega$$

$$X_C = \frac{Q}{I_{Z_2}^2} = \frac{2291.26 \text{ VAR}}{(4.790 \text{ A})^2} = 99.88 \Omega$$

17. a. $P_T = 5 \text{ kW}, Q_T = 6 \text{ kVAR}(L)$

$$S_T = \sqrt{P_T^2 + Q_T^2} = 7.81 \text{ kVA}$$

b. $F_p = \frac{P_T}{S_T} = \frac{5 \text{ kW}}{7.81 \text{ kVA}} = 0.640 \text{ (lagging)}$

c. $I_s = \frac{S_T}{E} = \frac{7,810 \text{ VA}}{120 \text{ V}} = 65.08 \text{ A}$

d. $X_C = \frac{1}{2\pi f C}, Q_C = I^2 X_C = \frac{E^2}{X_C} = \frac{(120 \text{ V})^2}{X_C}$
and $X_C = \frac{(120 \text{ V})^2}{Q_C} = \frac{14,400}{6000} = 2.4 \Omega$

$$C = \frac{1}{2\pi f X_C} = \frac{1}{(2\pi)(60 \text{ Hz})(2.4 \Omega)} = 1105 \mu\text{F}$$

e. $S_T = EI_s = P_T$

$$\therefore I_s = \frac{P_T}{E} = \frac{5000 \text{ W}}{120 \text{ V}} = 41.67 \text{ A}$$

19. a. $Z_T = R_1 + R_2 + R_3 + jX_L - jX_C$
 $= 2 \Omega + 3 \Omega + 1 \Omega + j3 \Omega - j12 \Omega = 6 \Omega - j9 \Omega = 10.82 \Omega \angle -56.31^\circ$

$$I = \frac{E}{Z_T} = \frac{50 \text{ V} \angle 0^\circ}{10.82 \Omega \angle -56.31^\circ} = 4.62 \text{ A} \angle 56.31^\circ$$

$$P = VI \cos \theta = (50 \text{ V})(4.62 \text{ A}) \cos 56.31^\circ = 128.14 \text{ W}$$

b. a-b: $P = I^2 R = (4.62 \text{ A})^2 2 \Omega = 42.69 \text{ W}$

b-c: $P = I^2 R = (4.62 \text{ A})^2 3 \Omega = 64.03 \text{ W}$

a-c: $42.69 \text{ W} + 64.03 \text{ W} = 106.72 \text{ W}$

a-d: 106.72 W

c-d: 0 W

d-e: 0 W

f-e: $P = I^2 R = (4.62 \text{ A})^2 1 \Omega = 21.34 \text{ W}$

$$21. \quad a. \quad R = \frac{P}{I^2} = \frac{80 \text{ W}}{(4 \text{ A})^2} = 5 \, \Omega, \quad Z_T = \frac{E}{I} = \frac{200 \text{ V}}{4 \text{ A}} = 50 \, \Omega$$

$$X_L = \sqrt{Z_T^2 - R^2} = \sqrt{(50 \, \Omega)^2 - (5 \, \Omega)^2} = 49.75 \, \Omega$$

$$L = \frac{X_L}{2\pi f} = \frac{49.75 \, \Omega}{(2\pi)(60 \text{ Hz})} = 132.03 \text{ mH}$$

$$b. \quad R = \frac{P}{I^2} = \frac{90 \text{ W}}{(3 \text{ A})^2} = 10 \, \Omega$$

$$c. \quad R = \frac{P}{I^2} = \frac{60 \text{ W}}{(2 \text{ A})^2} = 15 \, \Omega, \quad Z_T = \frac{E}{I} = \frac{200 \text{ V}}{2 \text{ A}} = 100 \, \Omega$$

$$X_L = \sqrt{Z_T^2 - R^2} = \sqrt{(100 \, \Omega)^2 - (15 \, \Omega)^2} = 98.87 \, \Omega$$

$$L = \frac{X_L}{2\pi f} = \frac{98.87 \, \Omega}{376.8} = 262.39 \text{ mH}$$

CHAPTER 19 (Even)

2. a. $Z_T = 3 \Omega - j5 \Omega + j9 \Omega = 3 \Omega + j4 \Omega = 5 \Omega \angle 53.13^\circ$
 $I = \frac{E}{Z_T} = \frac{50 \text{ V} \angle 0^\circ}{5 \Omega \angle 53.13^\circ} = 10 \text{ A} \angle -53.13^\circ$
R: $P = I^2 R = (10 \text{ A})^2 3 \Omega = 300 \text{ W}$
L: $P = 0 \text{ W}$
C: $P = 0 \text{ W}$
- b. **R:** $Q = 0 \text{ VAR}$
C: $Q_C = I^2 X_C = (10 \text{ A})^2 5 \Omega = 500 \text{ VAR}$
L: $Q_L = I^2 X_L = (10 \text{ A})^2 9 \Omega = 900 \text{ VAR}$
- c. **R:** $S = 300 \text{ VA}$
C: $S = 500 \text{ VA}$
L: $S = 900 \text{ VA}$
- d. $P_T = 300 \text{ W}$
 $Q_T = Q_L - Q_C = 400 \text{ VAR(L)}$
 $S_T = \sqrt{P_T^2 + Q_T^2} = EI = (50 \text{ V})(10 \text{ A}) = 500 \text{ VA}$
 $F_p = \frac{P_T}{S_T} = \frac{300 \text{ W}}{500 \text{ VA}} = 0.6 \text{ lagging}$
- e. —
- f. $W_R = \frac{VI}{f_1}$; $W_R = 2 \left[\frac{VI}{f_2} \right] = 2 \left[\frac{VI}{2f_1} \right] = \frac{VI}{f_1}$
 $V = IR = (10 \text{ A})(3 \Omega) = 30 \text{ V}$
 $W_R = \frac{(30 \text{ V})(10 \text{ A})}{60 \text{ Hz}} = 5 \text{ J}$
- g. $V_C = IX_C = (10 \text{ A})(5 \Omega) = 50 \text{ V}$
 $W_C = \frac{VI}{\omega_1} = \frac{(50 \text{ V})(10 \text{ A})}{(2\pi)(60 \text{ Hz})} = 1.327 \text{ J}$
 $V_L = IX_L = (10 \text{ A})(9 \Omega) = 90 \text{ V}$
 $W_L = \frac{VI}{\omega_1} = \frac{(90 \text{ V})(10 \text{ A})}{376.8} = 2.389 \text{ J}$
4. a. $P_T = 600 \text{ W} + 500 \text{ W} + 100 \text{ W} = 1200 \text{ W}$
 $Q_T = 1200 \text{ VAR(L)} + 600 \text{ VAR(L)} - 600 \text{ VAR(C)} = 1200 \text{ VAR(L)}$
 $S_T = \sqrt{P_T^2 + Q_T^2} = \sqrt{(1200 \text{ W})^2 + (1200 \text{ VAR})^2} = 1697 \text{ VA}$
- b. $F_p = \frac{P_T}{S_T} = \frac{1200 \text{ W}}{1697 \text{ VA}} = 0.7071 \text{ (lagging)}$
- c. —

d. $I_s = \frac{S_T}{E} = \frac{1697 \text{ VA}}{200 \text{ V}} = 8.485 \text{ A}, 0.7071 \Rightarrow 45^\circ \text{ (lagging)}$
 $I_s = 8.485 \text{ A } \angle -45^\circ$

6. a. $I_R = \frac{60 \text{ V } \angle 30^\circ}{20 \Omega \angle 0^\circ} = 3 \text{ A } \angle 30^\circ$
 $P = I^2 R = (3 \text{ A})^2 20 \Omega = 180 \text{ W}$
 $Q_R = 0 \text{ VAR}$
 $S = P = 180 \text{ VA}$

b. $I_L = \frac{60 \text{ V } \angle 30^\circ}{10 \Omega \angle 90^\circ} = 6 \text{ A } \angle -60^\circ$
 $P_L = 0 \text{ W}$
 $Q_L = I^2 X_L = (6 \text{ A})^2 10 \Omega = 360 \text{ VAR(L)}$
 $S = Q = 360 \text{ VA}$

c. $P_T = 180 \text{ W} + 400 \text{ W} = 580 \text{ W}$
 $Q_T = 600 \text{ VAR(L)} + 360 \text{ VAR(L)} = 960 \text{ VAR(L)}$
 $S_T = \sqrt{(580 \text{ W})^2 + (960 \text{ VAR})^2} = 1121.61 \text{ VA}$
 $F_p = \frac{P_T}{S_T} = \frac{580 \text{ W}}{1121.61 \text{ VA}} = 0.517 \text{ (lagging)} \quad \theta = 58.87^\circ$

d. $S_T = EI_s$
 $I_s = \frac{S_T}{E} = \frac{1121.61 \text{ VA}}{60 \text{ V}} = 18.69 \text{ A}$
 $\theta_{I_s} = 30^\circ - 58.87^\circ = -28.87^\circ$
 $I_s = 18.69 \text{ A } \angle -28.87^\circ$

8. a. $R - L: \quad I = \frac{50 \text{ V } \angle 60^\circ}{5 \Omega \angle 53.13^\circ} = 10 \text{ A } \angle 6.87^\circ$
 $P_R = I^2 R = (10 \text{ A})^2 3 \Omega = 300 \text{ W}$
 $P_L = 0 \text{ W}$
 $P_C = 0 \text{ W}$

b. $Q_R = 0 \text{ VAR}$
 $Q_L = I^2 X_L = (10 \text{ A})^2 4 \Omega = 400 \text{ VAR}$
 $I_C = \frac{50 \text{ V } \angle 60^\circ}{10 \Omega \angle -90^\circ} = 5 \text{ A } \angle 150^\circ$
 $Q_C = I^2 X_C = (5 \text{ A})^2 10 \Omega = 250 \text{ VAR}$

c. $S_R = P = 300 \text{ VA}$
 $S_L = Q_L = 400 \text{ VA}$
 $S_C = Q_C = 250 \text{ VA}$

d. $P_T = P_R = 300 \text{ W}$
 $Q_T = 400 \text{ VAR(L)} - 250 \text{ VAR(C)} = 150 \text{ VAR(L)}$
 $S_T = \sqrt{(300 \text{ W})^2 + (150 \text{ VAR})^2} = 335.41 \text{ VA}$

$$F_p = \frac{P_T}{S_T} = \frac{300 \text{ W}}{335.41 \text{ VA}} = 0.894 \text{ (lagging)}$$

e. —

$$\begin{aligned} \text{f. } I_s &= \frac{S_T}{E} = \frac{335.41 \text{ VA}}{50 \text{ V}} = 6.71 \text{ A} \\ 0.894 &\Rightarrow 26.62^\circ \text{ lagging} \\ \theta &= 60^\circ - 26.62^\circ = 33.38^\circ \\ I_s &= 6.71 \text{ A } \angle 33.38^\circ \end{aligned}$$

$$\begin{aligned} 10. \text{ a. } I_s &= \frac{S_T}{E} = \frac{10,000 \text{ VA}}{200 \text{ V}} = 50 \text{ A} \\ 0.5 &\Rightarrow 60^\circ \text{ leading} \\ \therefore I_s &\text{ leads } E \text{ by } 60^\circ \\ Z_T &= \frac{E}{I_s} = \frac{200 \text{ V } \angle 0^\circ}{50 \text{ A } \angle 60^\circ} = 4 \Omega \angle -60^\circ = 2 \Omega - j3.464 \Omega = R - jX_C \end{aligned}$$

$$\text{b. } F_p = \frac{P_T}{S_T} \Rightarrow P_T = F_p S_T = (0.5)(10,000 \text{ VA}) = 5000 \text{ W}$$

$$\begin{aligned} 12. \text{ a. } P_T &= 0 + 300 \text{ W} = 300 \text{ W} \\ Q_T &= 600 \text{ VAR}(C) + 200(L) = 400 \text{ VAR}(C) \\ S_T &= \sqrt{P_T^2 + Q_T^2} = 500 \text{ VA} \\ F_p &= \frac{P_T}{S_T} = \frac{300 \text{ W}}{500 \text{ VA}} = 0.6 \text{ (leading)} \end{aligned}$$

$$\begin{aligned} \text{b. } I_s &= \frac{S_T}{E} = \frac{500 \text{ VA}}{30 \text{ V}} = 16.67 \text{ A} \\ F_p &= 0.6 \Rightarrow 53.13^\circ \\ I_s &= 16.67 \text{ A } \angle 53.13^\circ \end{aligned}$$

c. —

d. Load: 600 VAR(C), 0 W

$$R = 0, L = 0, Q_C = I^2 X_C \Rightarrow X_C = \frac{Q_C}{I^2} = \frac{600 \text{ VAR}}{(16.67 \text{ A})^2} = 2.159 \Omega$$

$$\begin{aligned} \text{Load: } 200 \text{ VAR}(L), 300 \text{ W} \\ C = 0, R &= P/I^2 = 300 \text{ W}/(16.67 \text{ A})^2 = 1.079 \Omega \end{aligned}$$

$$X_L = \frac{Q_L}{I^2} = \frac{200 \text{ VAR}}{(16.67 \text{ A})^2} = 0.7197 \Omega$$

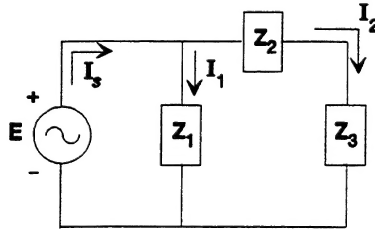
$$\begin{aligned} Z_T &= -j2.159 \Omega + 1.079 \Omega + j0.7197 \Omega \\ &= 1.079 \Omega - j1.4393 \Omega \end{aligned}$$

$$\begin{aligned} 14. \text{ a. } P_T &= 200 \text{ W} + 30 \text{ W} + 0 = 230 \text{ W} \\ Q_T &= 0 + 40 \text{ VAR}(L) + 100 \text{ VAR}(L) = 140 \text{ VAR}(L) \\ S_T &= \sqrt{P_T^2 + Q_T^2} = 269.26 \text{ VA} \end{aligned}$$

$$F_p = \frac{P_T}{S_T} = \frac{230 \text{ W}}{269.26 \text{ VA}} = 0.854 \text{ (lagging)} \Rightarrow 31.35^\circ$$

b. $I_s = \frac{S_T}{E} = \frac{269.26 \text{ VA}}{100 \text{ V}} = 2.6926 \text{ A}$
 $I_s = 2.6926 \text{ A} \angle -31.35^\circ$

c.



$$Z_1: R = \frac{V^2}{P} = \frac{10^4}{200} = 50 \Omega$$

$$X_L, X_C = 0 \Omega$$

$$I_1 = \frac{100 \text{ V} \angle 0^\circ}{50 \Omega \angle 0^\circ} = 2 \text{ A} \angle 0^\circ$$

$$I_2 = I_s - I_1$$

$$= 2.6926 \text{ A} \angle -31.35^\circ - 2 \text{ A} \angle 0^\circ$$

$$= 2.299 \text{ A} - j1.40 \text{ A} - 2.0 \text{ A}$$

$$= 0.299 \text{ A} - j1.40 \text{ A}$$

$$= 1.432 \text{ A} \angle -77.94^\circ$$

$$Z_2: R = \frac{P}{I_2^2} = \frac{30 \text{ W}}{(1.432 \text{ A})^2} = 14.63 \Omega, X_L = \frac{Q}{I_2^2} = \frac{40 \text{ VAR}}{(1.432 \text{ A})^2} = 19.50 \Omega$$

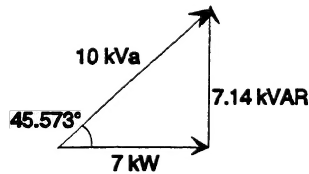
$$X_C = 0 \Omega$$

$$Z_3: X_L = \frac{Q}{I_2^2} = \frac{100 \text{ VAR}}{(1.432 \text{ A})^2} = 48.76 \Omega, R = 0 \Omega, X_C = 0 \Omega$$

16. a. $0.7 \Rightarrow 45.573^\circ$

$$P = S \cos \theta = (10 \text{ kVA})(0.7) = 7 \text{ kW}$$

$$Q = S \sin \theta = (10 \text{ kVA})(0.714) = 7.14 \text{ kVAR(L)}$$



b. $Q_C = 7.14 \text{ kVAR} = \frac{V^2}{X_C}$

$$X_C = \frac{V^2}{Q_C} = \frac{(208 \text{ V})^2}{7.14 \text{ kVAR}} = 6.059 \Omega$$

$$X_C = \frac{1}{2\pi f C} \Rightarrow C = \frac{1}{2\pi f X_C} = \frac{1}{(2\pi)(60 \text{ Hz})(6.059 \Omega)} = 438 \mu\text{F}$$

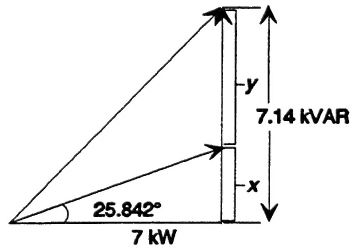
c. Uncompensated:

$$I_s = \frac{S_T}{E} = \frac{10,000 \text{ VA}}{208 \text{ V}} = 48.08 \text{ A}$$

Compensated:

$$I_s = \frac{S_T}{E} = \frac{P_T}{E} = \frac{7,000 \text{ W}}{208 \text{ V}} = 33.65 \text{ A}$$

d.



$$\begin{aligned}\cos \theta &= 0.9 \\ \theta &= \cos^{-1} 0.9 = 25.842^\circ \\ \tan \theta &= \frac{x}{7 \text{ kW}} \\ x &= (7 \text{ kW})(\tan 25.842^\circ) \\ &= (7 \text{ kW})(0.484) \\ &= 3.39 \text{ kVAR} \\ y &= (7.14 - 3.39) \text{ kVAR} \\ &= 3.75 \text{ kVAR}\end{aligned}$$

$$Q_C = 3.75 \text{ kVAR} = \frac{V^2}{X_C}$$

$$X_C = \frac{V^2}{Q_C} = \frac{(208 \text{ V})^2}{3.75 \text{ kVAR}} = 11.537 \Omega$$

$$C = \frac{1}{2\pi f X_C} = \frac{1}{(2\pi)(60 \text{ Hz})(11.537 \Omega)} = 230 \mu\text{F}$$

Uncompensated:

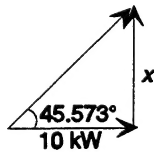
$$I_s = 48.08 \text{ A}$$

Compensated:

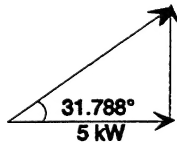
$$S_T = \sqrt{(7 \text{ kW})^2 + (3.39 \text{ kVAR})^2} = 7.778 \text{ kVA}$$

$$I_s = \frac{S_T}{E} = \frac{7.778 \text{ kVA}}{208 \text{ V}} = 37.39 \text{ A}$$

18. a. Load 1: $P = 20,000 \text{ W}$, $Q = 0 \text{ VAR}$
Load 2: $\theta = \cos^{-1} 0.7 = 45.573^\circ$



Load 3: $\theta = \cos^{-1} 0.85 = 31.788^\circ$



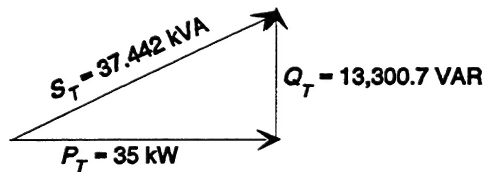
$$\begin{aligned}\tan \theta &= \frac{x}{10 \text{ kW}} \\ x &= (10 \text{ kW}) \tan 45.573^\circ \\ &= (10 \text{ kW})(1.02) \\ &= 10,202 \text{ VAR(L)}\end{aligned}$$

$$\begin{aligned}\tan \theta &= \frac{x}{5 \text{ kW}} \\ x &= (5 \text{ kW}) \tan 31.788^\circ \\ &= (5 \text{ kW})(0.62) \\ &= 3098.7 \text{ VAR(L)}\end{aligned}$$

$$P_T = 20,000 \text{ W} + 10,000 \text{ W} + 5,000 \text{ W} = 35 \text{ kW}$$

$$Q_T = 0 + 10,202 \text{ VAR} + 3098.7 \text{ VAR} = 13,300.7 \text{ VAR(L)}$$

$$S_T = \sqrt{P_T^2 + Q_T^2} = 37,442 \text{ VA} = 37.442 \text{ kVA}$$



$$\begin{aligned} \text{b. } Q_C &= Q_L = 13,300.7 \text{ VAR} \\ X_C &= \frac{E^2}{Q_C} = \frac{(10^3 \text{ V})^2}{13,300.7 \text{ VAR}} = 75.184 \Omega \\ C &= \frac{1}{2\pi f X_C} = \frac{1}{(2\pi)(60 \text{ Hz})(75.184 \Omega)} = 35.28 \mu\text{F} \end{aligned}$$

c. Uncompensated:

$$I_s = \frac{S_T}{E} = \frac{37.442 \text{ kVA}}{1 \text{ kV}} = 37.442 \text{ A}$$

Compensated:

$$\begin{aligned} S_T &= P_T = 35 \text{ kW} \\ I_s &= \frac{S_T}{E} = \frac{35 \text{ kW}}{1 \text{ kV}} = 35 \text{ A} \end{aligned}$$

$$\begin{aligned} 20. \text{ a. } S_T &= 660 \text{ VA} = EI_s \\ I_s &= \frac{660 \text{ VA}}{120 \text{ V}} = 5.5 \text{ A} \\ \theta &= \cos^{-1} 0.6 = 53.13^\circ \\ \therefore E &= 120 \text{ V } \angle 0^\circ, I_s = 5.5 \text{ A } \angle -53.13^\circ \\ P &= EI \cos \theta = (120 \text{ V})(5.5 \text{ A})(0.6) = 396 \text{ W} \\ \text{Wattmeter} &= 396 \text{ W, Ammeter} = 5.5 \text{ A, Voltmeter} = 120 \text{ V} \end{aligned}$$

$$\text{b. } Z_T = \frac{E}{I} = \frac{120 \text{ V } \angle 0^\circ}{5.5 \text{ A } \angle -53.13^\circ} = 21.82 \Omega \angle 53.13^\circ = 13.09 \Omega + j17.46 \Omega = R + jX_L$$

$$\begin{aligned} 22. \text{ a. } X_L &= 2\pi fL = (6.28)(50 \text{ Hz})(0.08 \text{ H}) = 25.12 \Omega \\ Z_T &= \sqrt{R^2 + X_L^2} = \sqrt{(4 \Omega)^2 + (25.12 \Omega)^2} = 25.44 \Omega \\ I &= \frac{E}{Z_T} = \frac{60 \text{ V}}{25.44 \Omega} = 2.358 \text{ A} \\ P &= I^2 R = (2.358 \text{ A})^2 4 \Omega = 22.24 \text{ W} \end{aligned}$$

$$\begin{aligned} \text{b. } I &= \sqrt{\frac{P}{R}} = \sqrt{\frac{30 \text{ W}}{7 \Omega}} = 2.07 \text{ A} \\ Z_T &= \frac{E}{I} = \frac{60 \text{ V}}{2.07 \text{ A}} = 28.99 \Omega \\ X_L &= \sqrt{(28.99 \Omega)^2 - (7 \Omega)^2} = 28.13 \Omega \\ L &= \frac{X_L}{2\pi f} = \frac{28.13 \Omega}{(2\pi)(50 \text{ Hz})} = 89.54 \text{ mH} \end{aligned}$$

$$\begin{aligned} \text{c. } P &= I^2 R = (1.7 \text{ A})^2 10 \Omega = 28.9 \text{ W} \\ Z_T &= \frac{E}{I} = \frac{60 \text{ V}}{1.7 \text{ A}} = 35.29 \Omega \\ X_L &= \sqrt{(35.29 \Omega)^2 - (10 \Omega)^2} = 33.84 \Omega \\ L &= \frac{X_L}{2\pi f} = \frac{33.84 \Omega}{314} = 107.77 \text{ mH} \end{aligned}$$